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Engineering Note

Date: August 29, 2002
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Project: Four Channel 200Watt Active Load for Power Supplies
Doc. No: H020829A

Subject: Active Load for Power Supply Testing

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1. Description

The Dummy Load Unit is an active power supply load that can be adjusted with a multi-turn control. The DLU is a building block that can be replicated to any level as required. Multiple units can be paralleled for larger current draws. Each unit is electrically isolated so they can be arranged to test +- power supplies.

A chassis containing 4 individual units is a general bench device that can be used during power supply testing and evaluation. This chassis construction as well as the DLU is described in this engineering note.

2. Operation

The DLU is a very simple device, connect the supply to the studs on the back of the chassis and control the current level with the pot on the front. The front panel meter provides visual feedback of the load current.

Each load unit is capable of dissipating a minimum 200Watts of power. Each unit is however limited to 20Amps of current. If the load is 5V then 20Amps of current can be drawn but only 100Watts will be dissipated. If the voltage is 10V then 20Amps can be drawn and 200Watts will be dissipated. At 15V approximately 13Amps can be handled and so on.

Each unit is self-contained, except for the cooling fans; therefore they can be connected as needed to provide special loading. That is they may be used on +/- supplies or paralleled to provide larger current loading.

The front panel holds an Ammeter, current control knob, momentary zero button and a 10-20 Amp full-scale range switch for each unit.

The momentary zero button is useful when testing power supplies that fold-back or when close to the trip point. The current can be lowered slightly and the zero button pressed to restore the supply without turning the current adjustment all the way down. Since the load is self powered some instablities may occur if the supply folds back during testing.

The range switch is used to set the full scale current to either 10 or 20Amps.

The chassis back panel contains stud connections for each load unit. Polarity should be observed to ensure proper operation. If the connections are reverse the unit will not draw any current. The positive terminal is on top.

3. Specification

Current Range: 20mA-10Amps / 20mA-20Amps set by the range switch on the front panel and controlled with the multi-turn pot. Note that the current does not go al the way to zero because there is a small quiescent current needed to operate the IC.

Voltage Range: ~3 to 40Volts with 500VDC common mode isolation between DLU and chassis ground.

Power dissipation: 200W per module minimum, 800W per chassis assembly. The DLU transistor is rated at 300W when the case is at 25°C and derates linearly to 0Watts at 200°C (see figure 1). The transistor case may operate 50°C above ambient at 200Watts.

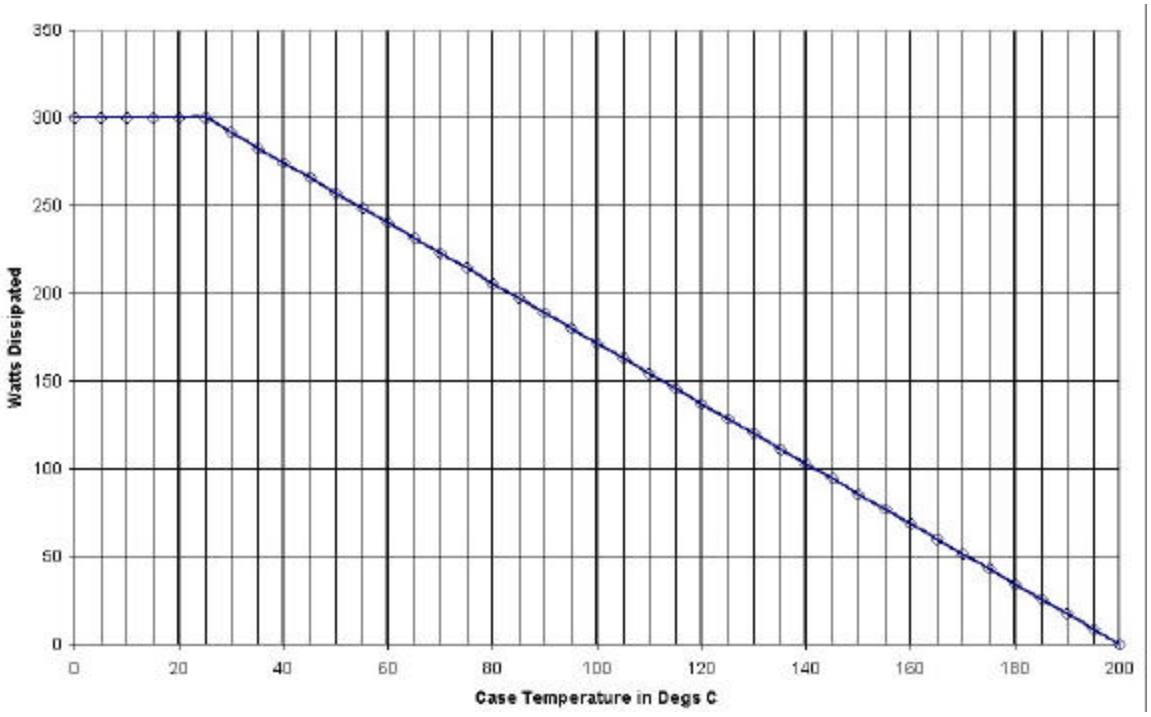

Figure 1 Transistor Power Dissipation vs. Temperature

Thermo-protection: the circuit is protected with a thermo switch set at 70°C. At this point the transistor can dissipate 223Watts as seen in figure 1. When the trip point is reached the base drive is removed from the transistor. The switch automatically resets when the temperature goes down 5 to 10 degress from the trip level.

Cooling: the chassis requires 120VAC to operate the fans that provide forced air-cooling. Air-cooling was chosen over water cooling to make the unit portable, compromising only the physical size and power dissipation levels. Care should be taken to ensure the air flow is not blocked during operation.

4. Schematic

This design is adapted from

Toffoli, Tommaso "Self-Powered Dummy load Checks Out multiple-Output Power Supplies"

ELECTRONIC DESIGN 'Ideas For Design' April 17, 2000, pg. 118.

The circuit is a simple series pass regulator using an OpAmp that contains a built-in voltage reference. The desired portion of the reference is compared with the output voltage across the shunt to provide the constant current load. The components connected to the base of the power transistor add stability and thermo protection.

A small PC board mounts directly to the transistor and holds most of the components.

The chassis holds four of these active loads and two fans for cooling.

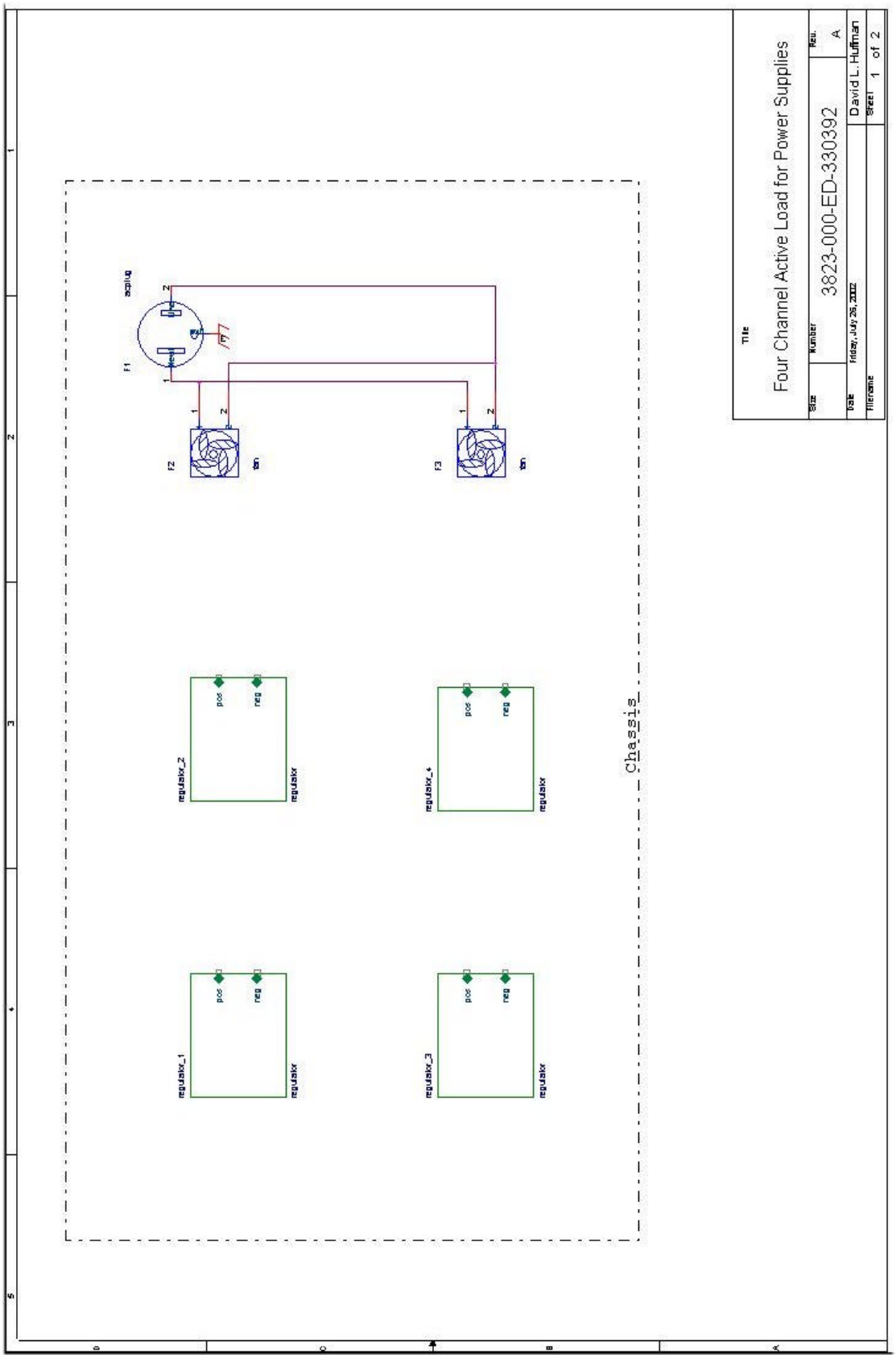

Figure 2 Top Level

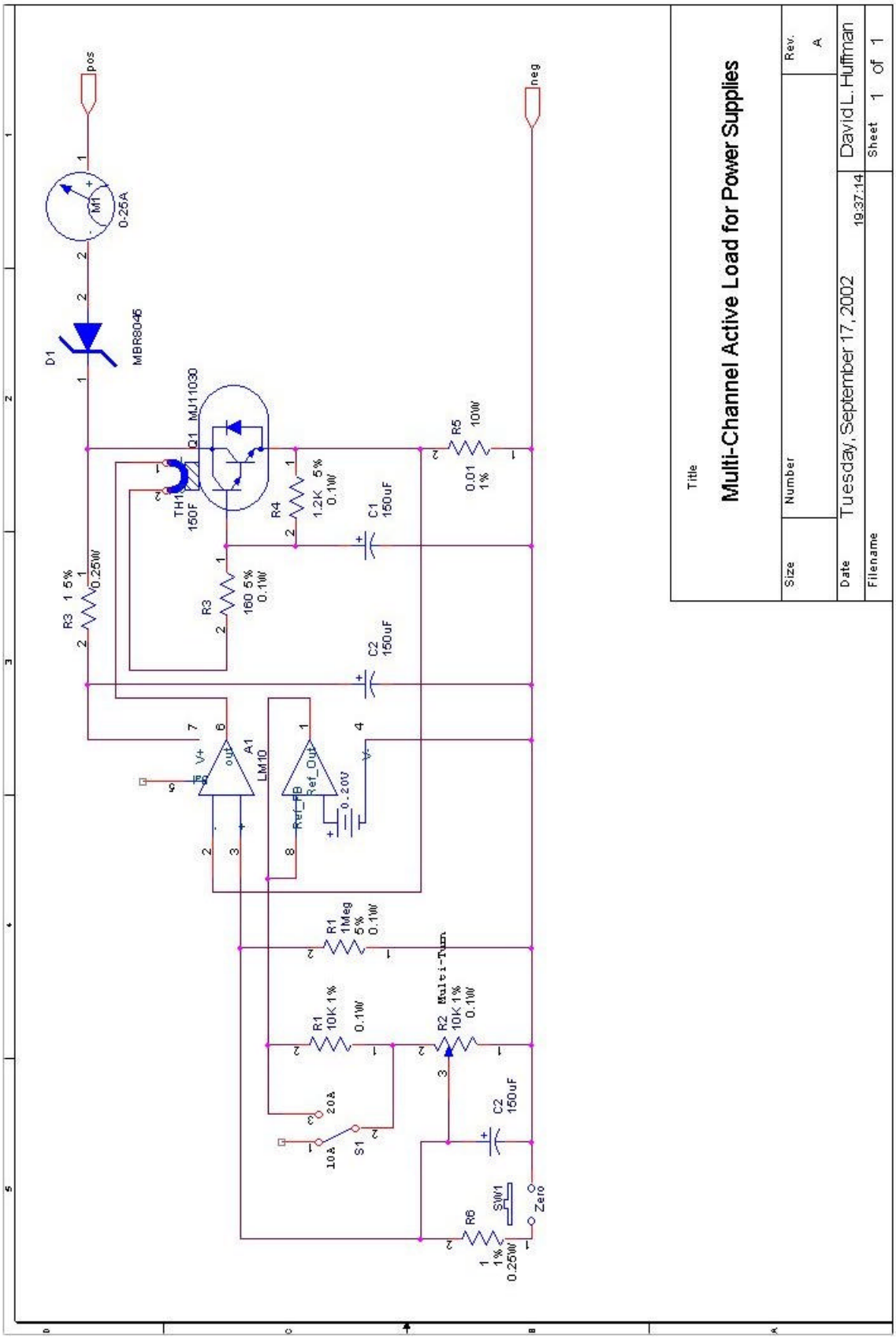

Figure 3 Load Unit Schematic

5. Mechanical Drawings

For the DLU to operate in a useful manner an efficient method to eliminate the dissipated power must be employed. A special copper heat sink spreads the heat to a larger set of aluminum extrusions allowing heat dissipation to the air. The idea is to keep the temperature rise on the transistor case to a minimum allowing the maximum power dissipation.

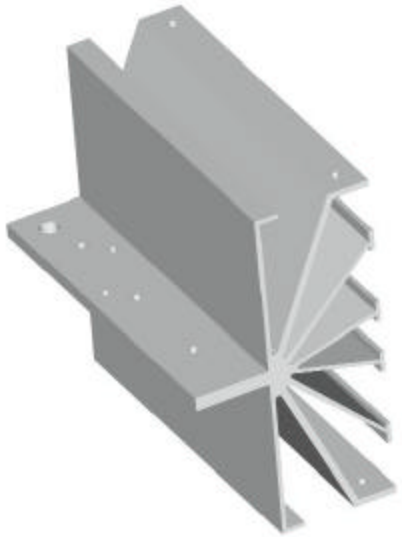

Figure 4 Aluminum Extrusions

The extrusion is drilled for mounting the copper heat spreader, thermo-switch and chassis mounting.

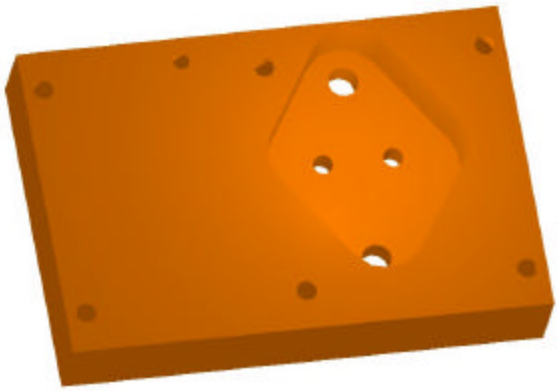

Figure 5 Copper Heat Spreader

The copper spreader holds the pass transistor and connects to two aluminum extrusions. It serves as the base for the regulator assembly.

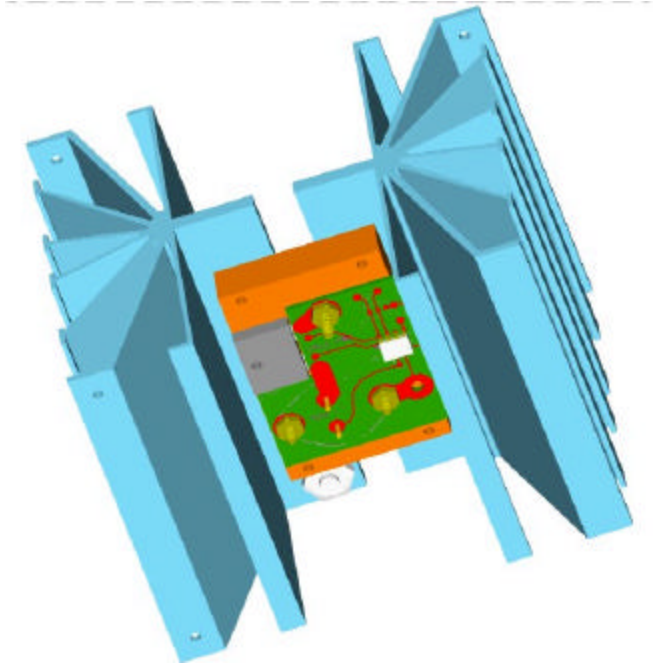

Figure 6 Regulator Assembly with Extrusions Bottom View

The printed circuit board mounts directly to the transistor and shunt. The copper heat spreader mounts to two aluminum extrusions.

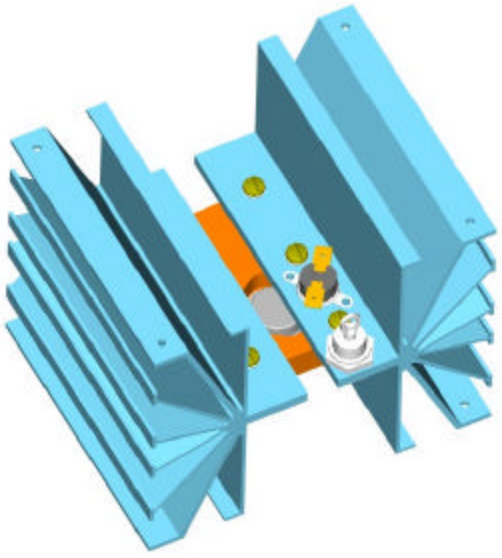

Figure 7 Regulator Assembly Top View

This view shows the thermo-switch mounting and the pass transistor buried in the pocket of the heat sink. The blocking diode mounts to the aluminum extrusion which is also electrically connected to the transistor case (collector).

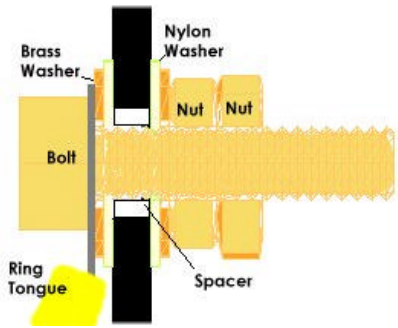

Figure 8 Rear Panel Stud Assembly Detail

The electrical connections on the back of the chassis are made with ¼" brass hardware. The bolts are isolated from the chassis with nylon washers and a centering space. The ring-tongue terminal makes the electrical connection to the front panel meter.

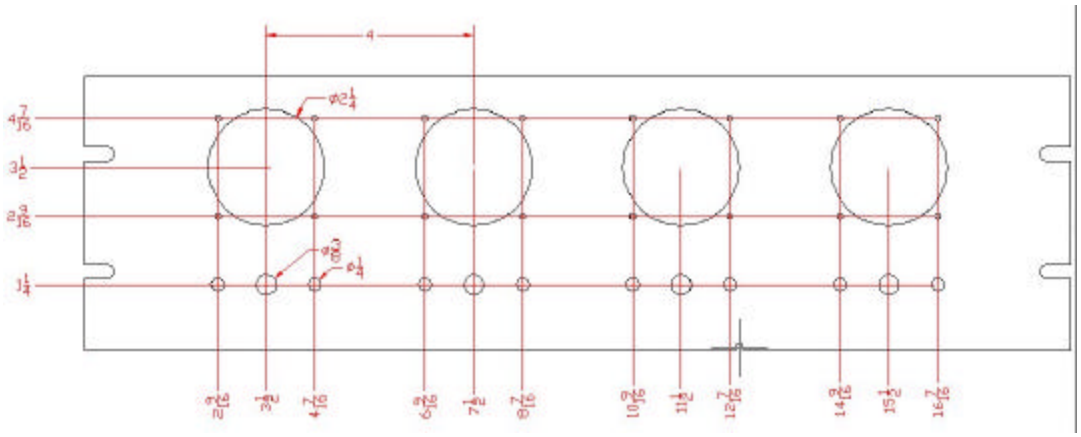

Figure 9 Front Panel Suggested Layout

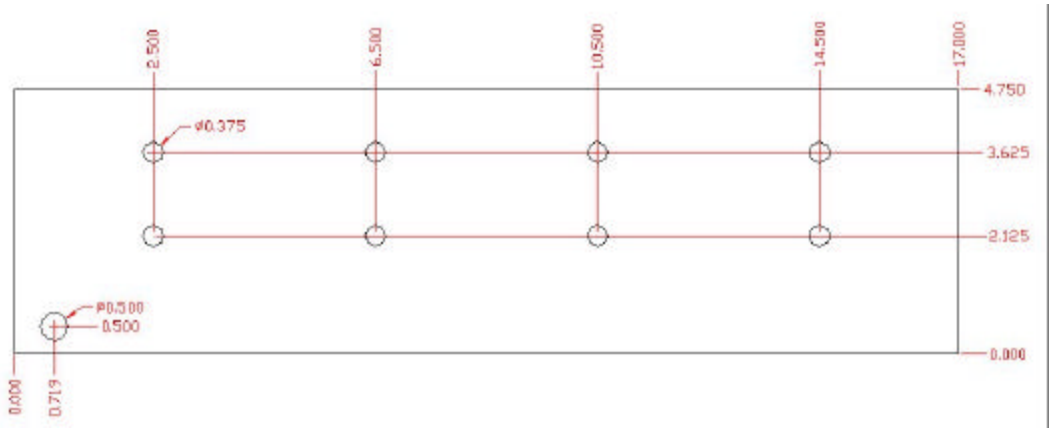

Figure 10 Back Panel Suggested Layout

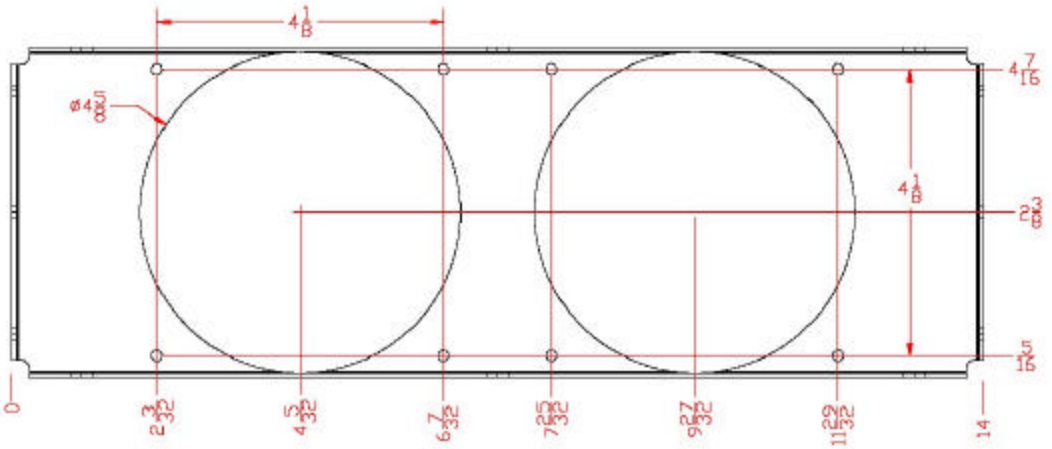

Figure 11 Side Panel Suggested Layout

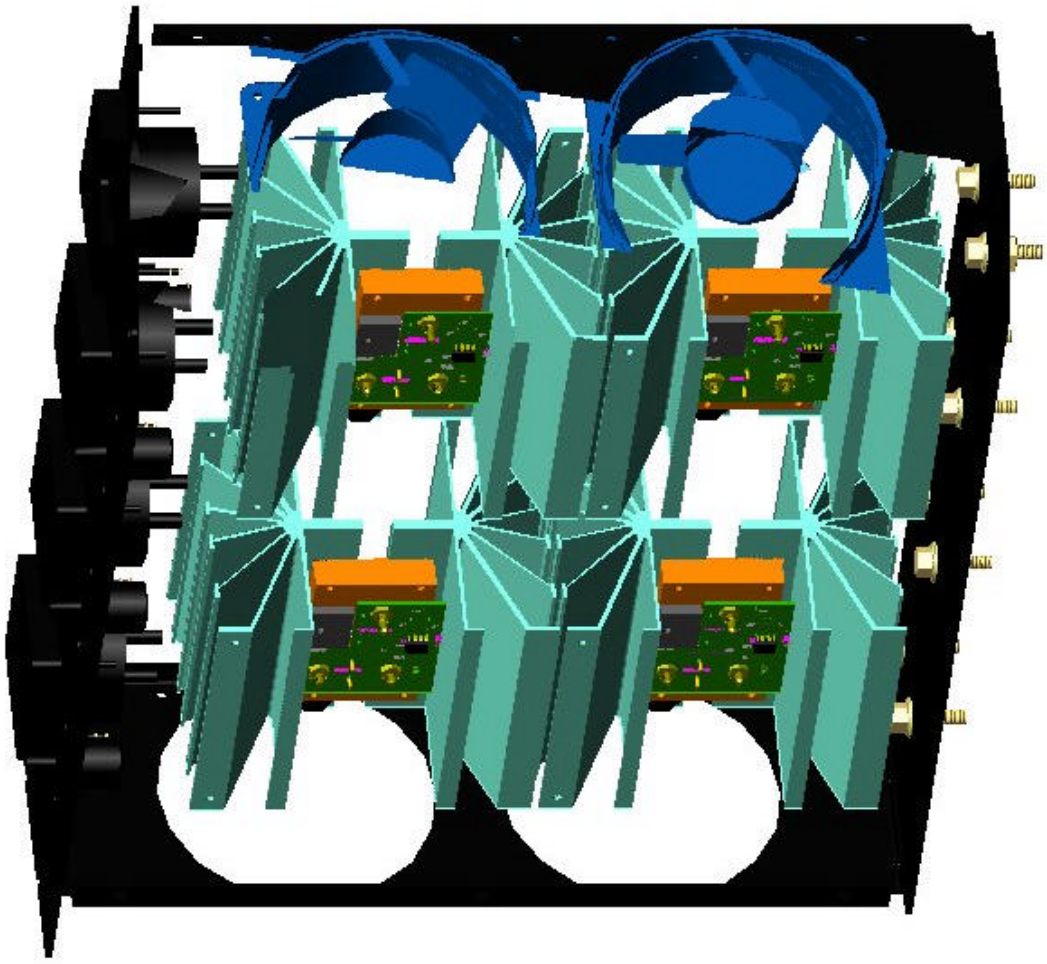

Figure 12 Chassis Assembly bottom cut-away view

6. BOM

Bill Of Materials September 3,2002 8 Units
12:00:00
2 Chassis

Item	Quantity	Reference	Part	Description	Stockroom Items	Unit Cost	Total Cost
Unit Regulator							
1	1	A1	LM10	OpAmp with voltage reference	LM10CN	$2.66	$21.28
2	3	C1,C2,C3	150uF	Electrolytic		$0.50	$12.00
3	1	M1	0-25A	Ampmeter	Model 1227	$15.00	$120.00
4	1	Q1	MJ11030	Power Transistor	MJ11030	$5.50	$44.00
5	1	R1	1Meg	5% 1/4W		$0.05	$0.40
6	2	R1,R2	10K	Multi-Turn Pot	3540S-1-103	$13.40	$214.40
7	1	R3	160	1% 1/4		$0.05	$0.40
8	2	R6,R3	1	wire wound 1/4W		$0.02	$0.32
9	1	R4	1.2K	5% 1/4W		$0.05	$0.40
10	1	R5	0.01	Shunt Resistor	PBV-R010	$2.03	$16.24
11	2	SW1	Zero	Momentary push button	1160-189000	$2.75	$44.00
12	1	S1	SW SPDT_0	Range switch	1160-200000	$7.00	$56.00
13	1	TH1	150F	Thermo Switch		$5.00	$40.00
14	1			Aluminum Heatsink	special	$10.00	$80.00
15	1			Copper heatsink	special	$0.01	$0.08
16	3		6-32	Brass Screw	1224-107500	$0.01	$0.24
17	1		6-32 x 1/2"	S.S. Screw	1226-256000	$0.10	$0.80
18	1		1/4-28	Brass Hex Nut		$0.10	$0.80
19	5		6-32	Brass Hex Nut		$0.02	$0.80
Chassis Assembly							
18	8	MT1,12	1/4-20 x 3/4"	Brass hexhead bolts	1224-117000	0.11	$1.76
19	2		Fan	Fan	1175-051000	$9.01	$36.04
20	2		Guard	Fan Guard	1175-055000	$1.16	$4.64
21	2		Cord	Fan cord & plug	1175-060000	$1.15	$4.60
22	2		Top/Bottom	Chassis Top & Bottom	1775-281000	$33.68	$134.72
23	2		Side	Chassis Sides	1775-257500	$31.05	$124.20
24	1		Front	Chassis Front	1775-240500	$15.60	$31.20
25	1		Back	Chassis Back	1775-244500	$11.65	$23.30
26	4		terminal	1/4-10Ga Ring Tongue	1110-428000	$0.17	$1.36
27	1		terminal	#6-10Ga Ring Tongue	1110-426500	$0.13	$0.26
28	8		#6 washer	Belleville Washer			$0.00
29	6		#8 washer	Belleville Washer			$0.00
30	6		8-32 x 1/2"	S.S. Screw	1226-161000	$0.01	$0.12
31	8		6-32	Nylon Hex Nut	1214-050000	$0.04	$0.64
32	8		6-32 x 1/2"	Nylon Screw	1230-100000	$0.08	$1.28
33	16	NT1,24	1/4-20 nut	Brass nuts			$0.00
34	16	NW1,24	1/4" washer	Nylon Flat Washer	1222-026000	$0.03	$0.96
35	1	F4	acplug	Plug and Cord	1170-134000	$3.25	$6.50
36							$0.00
37							$0.00
38							$0.00
							$1,023.74

7. Construction Techniques and Suggestions

Transistor Mounting

7.1.1. The transistor case must be in very good thermo-contact with the copper heat spreader and the spreader must be in good contact with the aluminum heatsinks. Heatsink compound must be used at both interfaces and only enough to displace the irregularities of the two surfaces. Too much will keep the transistor case from

actually touching the copper piece and to little will allow voids of air. Air is an excellent insulator so too much thermo compound is better than to little. The same theory applies for the copper to aluminum junction and the shunt.

7.1.2. Each mounting should be done using cupped washers (Belleville) to keep pressure applied to the joint. The thermo compound will migrate with time and the cupped washers will help maintain a good joint. Thermo-cycling will also cause the junction to loosen.

7.1.3. The copper heat spreader with the circuit board is an assembly. This assembly with the two aluminum extrusions is an assembly and is a single DLU without the front and rear panel components.

Load Unit Mounting

7.1.4. Each Dummy Load Unit is loosely mounted inside the chassis. The units merely sit on nylon screws that hold them in place when the top and bottom covers are installed.

Chassis Cooling

7.1.5. A cooling channel is required to keep airflow over the heatsinks. The front half and rear half act independently. This is accomplished with simple G10 spacers.

8. Addendum

A few 'good'[i] modifications have been added to the circuit to improve some areas of failure and instability.

Added a 1 Meg resistor to the wiper of the pot to keep the output from maxing out if the wiper contact opens.

Added an isolating resistor and filter capacitor to the OpAmp supply rail pin.

Added a series power Schottky diode to the circuit to prevent current flow when the unit is connected backwards.

The OpAmp is socketed for solder free replacement.

Complete mechanical drawings are available for all the components associated with this design.

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[i] Thanks to John Anderson for reviewing the design and pointing out these improvements.